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I, LEANNE MYNOTT, MANAGER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2004901112 for a patent by RAPIDJOINT PTY LTD as filed on 03 March 2004.

WITNESS my hand this
Tenth day of March 2005

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AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: **Improvements in Clamping Assemblies**

The invention is described in the following statement:

IMPROVEMENTS IN CLAMPING ASSEMBLIES

FIELD OF INVENTION

The present invention relates generally to adjustable clamps, and in particular to improvements in clamping assemblies of the type used to hold together flat surfaces, such as bench tops.

BACKGROUND OF INVENTION

An adjustable clamp is a device which is used, for example, to draw two objects together in a clamping action. Also, adjustable clamps can be used to hold objects away from each other.

A particular problem is encountered when trying to clamp together two elongate objects, end to end.

The problem can be appreciated from Figure 1 where objects A and B are to be clamped together end to end.

It would be impractical to use a standard clamp, of the type which seeks to compress items positioned between its jaws. For instance in Figure 1, it would be impractical to position a standard clamp around the end points A' and B', since, in practice, objects A and B may be very long. Moreover, if a standard clamp were to be placed over the end points A', B', a likely result when the clamping portions are brought together is that objects A and B may be forced out of linear alignment.

A known approach for clamping thin objects together end to end involves creating cut-out portions in the objects, and using clamps to pull the cut-out portions together. An example of a known cut-out arrangement is shown in Figure 2.

In Figure 2, the cut-out arrangement includes cut-away portions A" B" made in objects A and B respectively, so that a known clamp mechanism 200 can be inserted into the combined cut-away portion A", B".

The known clamp mechanism 200 includes a first clamp member 202 that abuts an inner surface 203 of cut-away portion B", and a second clamp member 204 that abuts a corresponding inner surface of cut-away portion A". The clamp members 202, 204 are connected by a shaft 206 that passes through respective holes (not shown) in the clamping members 202, 204. The shaft 206 is free to rotate within the holes in the clamping members 202, 204, and is provided with a

head portion 208 at one end that abuts an outer surface of the second clamping member 204.

The end of the shaft 206 opposed to the head 208 is provided with a screw thread 210, with which a nut 212 is threadably engaged. The nut 212 abuts an outer surface of the first clamping member 202. Accordingly, by tightening the nut 212, the two clamping members 204, 202 are drawn together, thus drawing the cut-away portions A", B" together in order to clamp together the objects A, B.

The problem remains, however, that it is difficult in many circumstances to manipulate the known clamp 200 in cut-away portions such as the one designated as A", B" in Figure 2. In order to tighten the nut 212, it is necessary to use a spanner or other form of lever arm, which requires the spanner or lever arm to be swept through an arc. Thus, when the clamp 200 resides in the cut-away portion A", B" it may be difficult to sweep the spanner or lever arm through the arc, because the walls and surface of the objects A, B tend to obstruct the sweep of the arc. At best, it is necessary to manipulate the spanner in very small increments, because the walls of the cut-away portion A", B" limit the sweep of the arc.

Exacerbating the difficulty is the fact that, in use, this form of clamping is often employed on the undersurfaces of benches or tables, where the inaccessibility of the clamp within a confined area may be a problem.

One clamp known in the prior art which attempts to overcome the above disadvantages is described in WO 03/035992. This prior art clamp provides a first beveled gear member at one end of the clamp mechanism. A special tool is then provided which engages with a pivot locator positioned in a clamp member located adjacent to the end of the clamp mechanism including the first beveled gear member. The tool includes a second beveled gear member that engages with the first beveled gear member, such that the clamp may be operated by a rotation of the tool about its axis, which lies perpendicular to the axis of the clamp mechanism. Accordingly, the clamp may be operated without the necessity to sweep a spanner or lever through an arc that is obstructed by the walls and surfaces of the objects A, B.

However, there remain a number of disadvantages of the clamp disclosed in WO 03/035992. First, the clamp requires a special tool for its operation. This

is a particular disadvantage for tradespersons, who are among the main users of these types of clamps, because the clamp tool must be stored, carried and kept on hand along with other tools of the trade. The clamp tool may easily be misplaced, lost, or simply not be within reach at the moment it is required. It is accordingly preferable that the clamp may be operated using a general purpose tool, such as a screwdriver or similar, that the tradesperson will always require and have on hand in the course of work.

Furthermore, applying a tightening torque using the tool, it may easily slip from the pivot locator, which may result in injury to the operator, and/or stripping of the beveled gears on the clamp mechanism and the tool.

A number of alternative clamp designs are described in the present inventors' prior International Patent Application No. PCT/AU03/01007 that overcome some of the problems known in earlier clamps. Embodiments disclosed therein employ either a cam or worm gear arrangement to provide clamps that may be manipulated using a standard screwdriver or the like rotated about an axis perpendicular to the axis of the clamp mechanism. An embodiment 300 using a worm gear arrangement is shown in Figure 3.

The adjustable clamp assembly 300 includes first and second clamp members 330, 320 having respective facing inner surfaces 331, 321 adapted to abut against the wall surfaces 203, 205 shown in Figure 2. The assembly 300 further includes a shaft 340 having a threaded portion 341 at one end.

A sleeve member 356 is provided which has an internal thread, enabling it to be connected to the threaded portion 341 of the shaft 340 by screw-thread engagement. The first clamp member 330 includes holes allowing the rod 340 to pass through.

A worm gear assembly 350 incorporates a worm gear 351 and a worm wheel 352. Accordingly, rotation of the worm gear 351 causes rotation of the sleeve 356, which in turn causes the inner surfaces 321, 331 of the clamp components 320, 330 to be either drawn together or apart along a path of linear motion, depending on the direction of the rotation of the sleeve.

The worm gear 351 is located within a bracket 354 that is integrally formed with the first clamp member 330. The first clamp member 330 thus consists of an

integral unit that enables the gear assembly to be entirely contained within one of the cut-away portions, *eg* A".

However, the clamp assemblies disclosed in PCT/AU03/01007 do not fully satisfy the needs of users of such clamps, since there remain certain problems with these assemblies. For example, the worm gear 351 is necessarily located out-board of the shaft 340 and sleeve 356. Accordingly, the clamp member 330 must be made sufficiently wide to accommodate the worm gear 351. It is clearly desirable to minimize the size of the clamp member 330 in order to reduce the size of the cut-away portion *eg* A" that must be made in the surface A. The size of the clamp member can be reduced if the diameter of the worm gear 351 is reduced, however this results in a reduction of the contact area between the thread of the worm gear 351 and the teeth of the worm wheel 352. The reduced contact area results in higher stress on these components, leading to an increased probability of damage to, or failure of, the gear assembly.

Furthermore, there may be a very high gear ratio provided by the worm gear assembly 350, typically in the range 10-20. While this was previously perceived to be an advantage of the arrangement 350, since it enables a high clamping force to be applied with reduced torque, the inventors have now discovered that the clamping force provided by the worm gear assembly 350 is far in excess of typical requirements. Since the application of excessive force may result in damage to the surfaces A, B, and/or damage to the clamp assembly such as stripping of the thread 341 or straining of the shaft 340, the high gear ratio may be undesirable. This is especially likely to be the case when the clamp is tightened using mechanical means, such as a motorized screwdriver or drill, which may apply a relatively high torque to the worm gear 351.

Accordingly, there remains an unmet need for an improved clamp assembly that provides the advantages of the assemblies disclosed in PCT/AU03/01007, including the ability to operate the clamp using a standard tool such as a screwdriver without interference from the surrounding surfaces, while at least mitigating the disadvantages of size and susceptibility to stress and/or damage that may be experienced with prior art clamps.

It is to be noted that any discussion of documents, devices, acts or knowledge in this specification is included to explain the context of the invention.

It should not be taken as an admission that any of the material formed part of the prior art base or the common general knowledge in the relevant art on or before the priority date of the claims herein.

SUMMARY OF THE INVENTION

In one aspect, the present invention provides an adjustable engagement assembly adapted to function as a clamp member when used in a clamp assembly of the type having a substantially cylindrical connection member with a threaded portion, the engagement assembly including:

a first bevel gear member having centrally a first axis of rotation;

a second bevel gear member including a central sleeve member having an internal thread for screw-thread engagement with a threaded cylindrical connection member, the second bevel gear member having centrally a second axis of rotation substantially perpendicular to said first axis and being cooperatively engaged with the first bevel gear member such that rotation of the first bevel gear member about the first axis results in rotation of the second bevel gear member about the second axis; and

a housing formed to retain therein said first and second bevel gear members in cooperative engagement with one another, and having at least one external surface that, in use, abuts a corresponding surface of an object to be clamped.

Accordingly, the invention provides for a compact clamping engagement assembly in which all components are retained within a housing that also functions as a clamping member in an assembled clamp. In particular, by use of a bevel gear arrangement in accordance with the invention, the need for out-board gearing components that must be positioned alongside the connection member when the assembly is in use, such as the worm gear arrangement known in the prior art, is avoided. Thus the size of the cut-away portion required to locate the engagement assembly is reduced. Furthermore, the bevel gear arrangement may have approximately unity gear ratio, or any other ratio as desired, so that the application of excessive forces to the gears, screw threads and/or other clamping components, that may occur especially when using power tools to tighten the clamp, may be avoided.

A further advantage of the invention is that the engagement assembly may include all of the moving parts in a completed clamp assembly, and the cylindrical connection member may be fixed in place with the second bevel gear member being able to rotate about the connection member in engagement with the threaded portion thereof, such that the engagement assembly moves along the threaded portion. Accordingly, the engagement assembly may be used with fixed connection members such as connection members preinstalled in one of the objects to be clamped together, such as in a through-hole arrangement.

Preferably the housing is formed from a resilient material, and in particular may be manufactured cost-effectively by injection moulding from a suitable plastic.

Preferably the housing includes a cylindrical channel that passes through said external surface, which is aligned with the sleeve member of the second bevel gear member so that, in use, a threaded connection member may be received via the channel to engage with the sleeve member.

In a preferred embodiment, the first bevel gear member includes a raised projection of circular cross-section, which is retained within a slot formed in an end face of the housing, the slot consisting of a substantially semicircular end portion having a diameter corresponding to that of the raised projection and an opposing neck portion having a slight narrowing at an opening adjacent to an open side of the cavity.

It is preferred that the second bevel gear member further includes a groove disposed about a circumference, and that the housing includes two rib members disposed adjacent to the open side of the cavity and formed to engage within the groove to retain the second bevel gear member in position. In a particularly preferred embodiment, the rib members are inwardly curved and terminate in bezel-ended projections that engage within the groove.

The first bevel gear member is preferably provided with a means for connecting with a tool for rotating the gear member about its axis. The connecting means may be a recess formed in the end face of the raised projection. The recess may be shaped to engage with a rotation mechanism, such as a manual or powered screwdriver or drill having a Phillips head engaging bit.

Preferably, the internal thread of the sleeve member is a left-hand thread for engaging with a corresponding left-hand thread of a connecting member. Advantageously, this enables the clamp to be tightened by clockwise rotation of the first bevel gear member, in accordance with usual convention.

In another aspect, the present invention provides an adjustable clamp assembly including:

a substantially cylindrical connection member having a threaded portion at one end thereof;

an adjustable engagement assembly adapted to function as a first clamp member; and

a second clamp member, disposed at an end of the connection member opposed to the end having the threaded portion;

wherein the adjustable engagement assembly includes:

a first bevel gear member having centrally a first axis of rotation;

a second bevel gear member including a central rotatable sleeve member having an internal thread in screw-thread engagement with the threaded portion of the connection member, the second bevel gear member having centrally a second axis of rotation substantially perpendicular to said first axis and being cooperatively engaged with the first bevel gear member such that rotation of the first bevel gear member about the first axis results in rotation of the second bevel gear member about the second axis; and

a housing formed to retain therein said first and second bevel gear members in cooperative engagement with one another, and having at least one external surface that, in use, abuts a corresponding surface of an object to be clamped so as to function as a first clamp member.

BRIEF DESCRIPTION OF THE DRAWINGS

Further benefits and advantages of the adjustable engagement assembly and clamp assembly of the present invention will become apparent in the following description of preferred embodiments of the invention, which should not, however, be considered to limit the scope of the invention or any of the preceding statements. In order that the invention might be more fully understood, embodiments of the invention will be described with reference to the accompanying drawings, in which:

Figure 1 is a side view of two flat objects which are to be clamped together end to end;

Figure 2 is a plan view of a prior art clamp positioned in a cut-away portion;

Figure 3 is a perspective view of another prior art clamp assembly;

Figure 4 is a perspective view of a complete clamp assembly in accordance with the present invention;

Figure 5 is an exploded view of a clamp assembly in accordance with the present invention, along with cut-away portions suitable for fitting the clamp assembly; and

Figure 6 shows a clamp assembly in accordance with the present invention when fully assembled and located within suitable cut-away portions;

DESCRIPTION OF PREFERRED EMBODIMENT

Figure 4 illustrates a preferred embodiment 400 of a clamp assembly in accordance with the present invention, while Figure 5 shows an exploded view of the same clamp assembly showing the separate parts, along with cut-away portions suitable for fitting the clamp assembly. Like reference numerals in each of the drawings indicate like components.

The embodiment 400 includes three main components: an adjustable engagement assembly 402 that acts as a first clamp member; a second clamp member 404; and an interconnecting shaft 406.

The adjustable engagement assembly 402 includes a housing 408, a first bevel gear member 410, and a second bevel gear member 412.

In the preferred embodiment 400, the housing 408 is formed of a resilient material. For example, the housing 408 may be injection moulded from a suitable plastic, which advantageously provides for a simple manufacturing process and accordingly low production cost.

The housing 408 is formed such that a curved outer surface 414 thereof is able to abut a corresponding curved surface of a cut-away portion formed in an object to be clamped. The housing 408 also includes opposed end faces 416, 418 which bracket the curved clamping surface 414. The clamping surface 414 and end faces 416, 418 form the outer surfaces of a wall that surrounds an interior cavity of the housing 408, the cavity being open at the side opposed to the surface 414.

A cylindrical channel 550 is formed in the housing 408, passing through the clamping surface 414 and emerging at the open side of the cavity. When the clamp is assembled, the shaft 406 passes through the channel 550. The diameter of the channel 550 is slightly larger than that of the shaft 406, so that the shaft is able to slide and/or rotate freely within the channel.

The first bevel gear member 410 includes a toothed bevel wheel 424, formed integrally and coaxially with a raised projection 426 having a circular cross-section. The cavity of the housing 408 includes a portion adjacent to end face 416 that is formed in a shape complementary to that of the bevel wheel 424. A slot 420 is formed in the end face 416 of the housing 408, the slot consisting of a substantially semicircular end portion having a diameter corresponding to that of the raised projection 426, and an opposing neck portion having a slight narrowing at an opening adjacent to the open side of the cavity. Due to the resilience of the material from which the housing 408 is formed, the neck portion is able to flex temporarily to allow the raised projection 426 of the first bevel gear member 410 to be inserted into the slot 420. When cooperatively engaged in the slot in this manner, the first bevel gear member 410 is able to rotate, however movement parallel to the axis of the shaft 406 is restrained by the slight narrowing in the neck of slot 420, while movement perpendicular to the axis of the shaft is restrained by the walls of the housing.

The second bevel gear member 412 includes a toothed bevel wheel 436 formed integrally and coaxially with a cylindrical sleeve member 438 having an internal thread (not shown). The interconnecting shaft 406 includes a threaded portion 440 at one end thereof, which connects, in use, by screw-thread engagement with the sleeve member 438 of the second bevel gear member 412.

The second bevel gear member 412 also includes a groove 422 disposed circumferentially adjacent to the teeth of the bevel wheel 436. The housing 408 includes two rib members 428, 430 disposed adjacent to the open side of the cavity and extending away from the clamping surface 414. The rib members 428, 430 are inwardly curved, and terminate in bezel-ended projections 432, 434. Due to the resilience of the material from which the housing 408 is formed, the rib members 428, 430 are able to flex temporarily to allow the second bevel gear member 412 to be inserted into the cavity of the housing 408 such that the

projections 432, 434 engage within the groove 422 with the threaded interior of the sleeve 438 aligned with the channel 550.

Accordingly, when the clamp assembly is in use the shaft 406 passes through the channel 550 so that the threaded portion 440 engages with the internal thread of the sleeve 438. The teeth of the bevel wheel 436 of the second bevel gear member 412 mesh with the teeth of the bevel wheel 424 of the first bevel gear member. The second bevel gear member 412 is held in place by engagement with the shaft 406, with the projections 432, 434 of the ribs 428, 430, and with the first bevel gear member 410. The engagement of the second bevel gear member 412 with the first bevel gear member 410 also assists in retaining the first bevel gear member 410 firmly in place within the slot 420. Thus when fully assembled, the engagement assembly forms a highly stable and robust structure in which all component parts are cooperatively held firmly in place.

The first bevel gear member 410 is further provided with a means for connecting with a tool for rotating the gear member 410 about its axis. In the preferred embodiment, the connecting means is a recess 442 formed in the end face of the raised projection 426, the recess being shaped to engage with a rotation mechanism, such as a manual or powered screwdriver or drill having a Phillips head engaging bit. It will be appreciated, however, that other formations may be provided for engaging with other types of rotation mechanism, such as standard flat-head engaging bits, spanner or socket heads, or Allen keys.

When the clamp assembly 400 is fully assembled, rotation of the first bevel gear member 410 through application of torque using a suitable rotation mechanism, results in rotation of the second bevel gear member 412, through the cooperative engagement of the teeth of the first bevel gear member 410 with those of the second bevel gear member 412. Accordingly, if the shaft 406 is restrained from rotating, then the rotation of the second bevel gear member 412 will result in translation of the shaft 406 along its axis by means of the screw thread engagement between the integral sleeve 438 and the threaded portion 440 of the shaft 406.

Preferably, the shaft 406 is provided with a left-hand thread, so that clockwise rotation of the first bevel gear member 410 by the rotation mechanism results in tightening of the clamp, in accordance with usual convention.

Through being arranged in this preferred manner, the housing 408 is adapted in accordance with the invention to retain the bevel gear members 410, 412 in cooperative engagement with one another in a manner that substantially minimises the space occupied by the gear assembly, while also acting as a first clamp member of the complete clamp assembly 400. Accordingly, the preferred embodiment 400 provides a particularly compact structure that enables the size of the cut-away portion to be substantially reduced in comparison to prior art clamp assemblies.

In the preferred clamp assembly 400, the second clamp member 404 includes a curved surface 551 for engaging with a corresponding surface of a cut-away portion. A rectangular slot 552 is formed in one side of the second clamp member 404 at approximately the centre of the curved face. A shoulder 554 having a square section is provided proximate to the end of the rod 406 opposed to the threaded portion 440, and a round head 556 is formed behind the shoulder 554, having a flat surface 558 adjacent to the shoulder 554.

Accordingly, when the second clamping member 404 is slotted over the square shoulder as shown, the head 556 rests against the second clamp member 404, preventing movement of the rod 406 through the slot 552, and the sides of the shoulder abut the walls of the slot 552. This arrangement ensures that the rod 406 is not able to rotate relative to the second clamp member 404 when the first bevel gear member 410 is rotated causing the second bevel gear member 412 and sleeve 438 to rotate.

In Figure 6, the clamp assembly is shown fully assembled and inserted into suitable cut-away portions 606, 608 formed in two flat objects 602, 604. The figure illustrates that the exterior surface of the housing 408, including the ribs 428, 430, and the opposed surface of the second clamp member 404, all have the form of circular arcs. Accordingly, the clamp assembly 400 can be fitted within cut-away portions consisting only of straight sections to accommodate the shaft 406 and circular portions to accommodate the engagement assembly 402 and second clamp member 404.

Furthermore, the complete engagement assembly 402 is sufficiently compact to be able to fit within a circular cut-away portion of a size suitable to accommodate the second clamp member 404. Thus there is no need to cut

larger cut-away portions only to accommodate the engagement assembly. Since circular cut-away portions are generally simpler, and therefore cheaper, to form than more irregular shapes, there is no additional cost penalty incurred by providing a complete circular cut-away portion for the second clamp member 404. Overall, therefore, a clamp assembly in accordance with the present invention provides a solution that may reduce the costs of clamping together flat objects by the cut-away method.

Additionally, it can be demonstrated that a clamping assembly according to the present invention achieves the aforementioned advantages while also providing for sufficient clamping force to meet the requirements of typical applications, without providing excessive clamping force that may result in damage to the clamping assembly, or the objects to be clamped together.

The clamping force can be related to the applied tightening torque using the well-known torque-tension relationship:

$$T = FDK$$

In the foregoing equation, T is the applied torque, F is the resulting clamping force, D is the effective diameter of the threaded shaft, and K is the torque-tension coefficient, or so-called "nut factor".

For a uniform screw thread, without defects of variations in friction, the nut factor may be calculated from:

$$K = \frac{1}{2}\left(\frac{p + \pi\mu D \sec\alpha}{\pi D - \mu p \sec\alpha}\right)$$

In the foregoing equation, p is the pitch of the screw thread, μ is the coefficient of friction between the threaded members, and α is the angle of the screw thread, defined as shown in Figure 2.

Considering firstly the well-known prior art clamp as shown in Figure 1, for a standard metric M6 thread, $D = 5.459$ mm, $p = 1$ mm and $\alpha = 30$ degrees. The coefficient of friction μ typically varies between 0.1 and 0.2. Accordingly, K is in the range 0.17496 to 0.29319.

If a force of 5 kg (50 N) is applied using a ring spanner 100 mm in length, to produce a torque of 5 Nm, the clamping force using the prior art clamp 200 will be between 6248 N and 10470 N.

This calculation does not take into account the loss due to friction between the nut 212 and the clamping member 202. If this friction is accounted for, assuming an effective diameter of the nut to be about 8 mm, then the minimum clamping force is reduced from 6248 N to approximately 3124 N.

If the worm gear arrangement of the clamp 300 shown in Figure 3 is employed, then the gear ratio is typically in the range 10-20. Assuming the gear efficiency (due to friction) is in the range 0.2 to 0.4, if a torque of 5 Nm is applied to the worm drive assembly, for example using a cordless drill, then the torque applied to the worm wheel 352 (corresponding to the nut 212 in the clamp 200) is between 10 Nm and 40 Nm. This provides a clamping force between 15620 N and 62480 N. This is clearly an excessive force, in view of the fact that the clamp 200, although awkward to use, is known to provide adequate clamping force for typical application. Indeed, such high force creates a risk of damage to the screw thread, gears or other components of the assembly, particularly when power tools are used for tightening.

Since the bevel gear arrangement of the present invention will typically have close to 1:1 ratio between the two gear members 410, 412, the clamping force applied by the arrangement will be of similar magnitude to that provided by the well-known clamp 200. There will be a slight reduction in force, due to the losses resulting from friction between the bevel gears, however this will be compensated to some degree by the fact that the clamp of the present invention can be tightened using a power tool, such as a cordless drill or power screwdriver, which should allow a larger torque to be applied in most cases than would be possible by the use of a spanner with the prior art clamp 200.

It will be appreciated that the foregoing embodiments have been advanced by way of example only, and modifications are possible within the scope of the invention. For example, while the clamp assembly described includes a cylindrical connection member 406 intended to be installed in a cut-away portion in engagement with clamping member 404, it will be appreciated that since all moving parts in the assembly are included in an engagement assembly according to the invention, the engagement assembly may be employed with cylindrical connection members installed using other arrangements. For example, an engagement assembly may be engaged with a threaded portion of a connection

member that has been preinstalled in an end of one of the objects to be clamped together, or that has been installed into an object using a through-hole rather than cut-away arrangement.

DATED this 3rd day of March 2004

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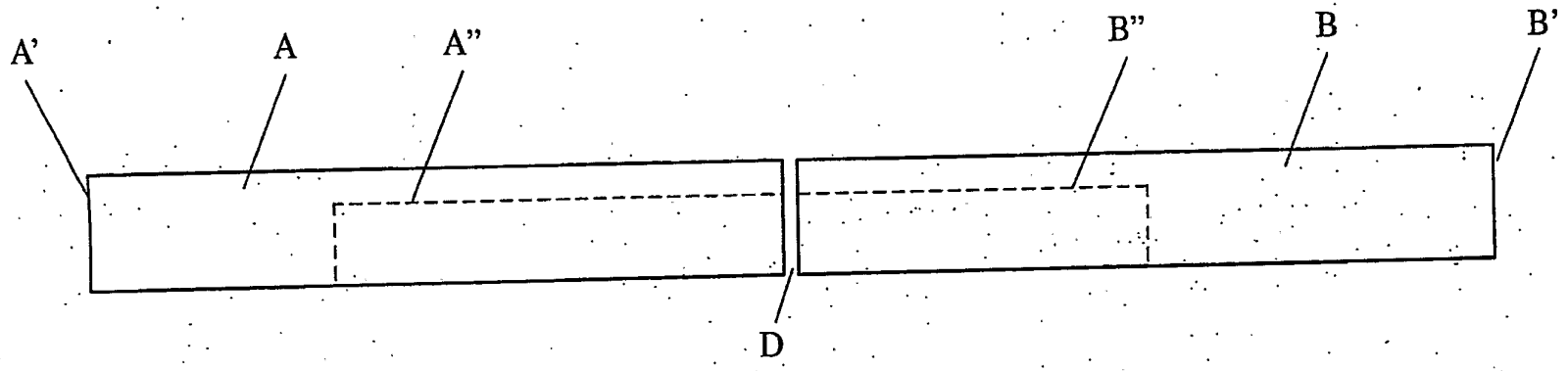

FIGURE 1

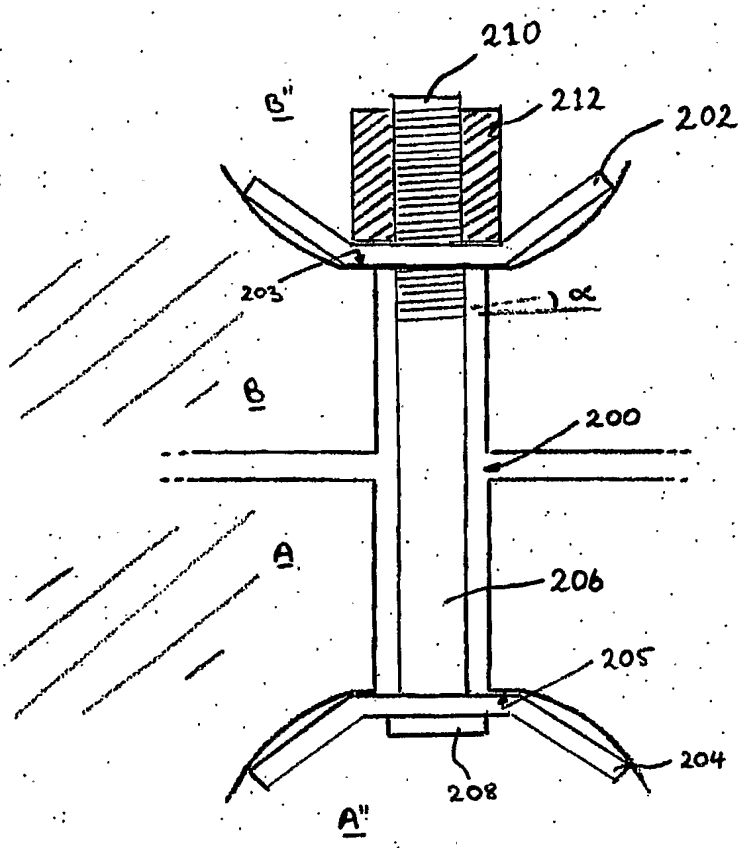

FIGURE 2

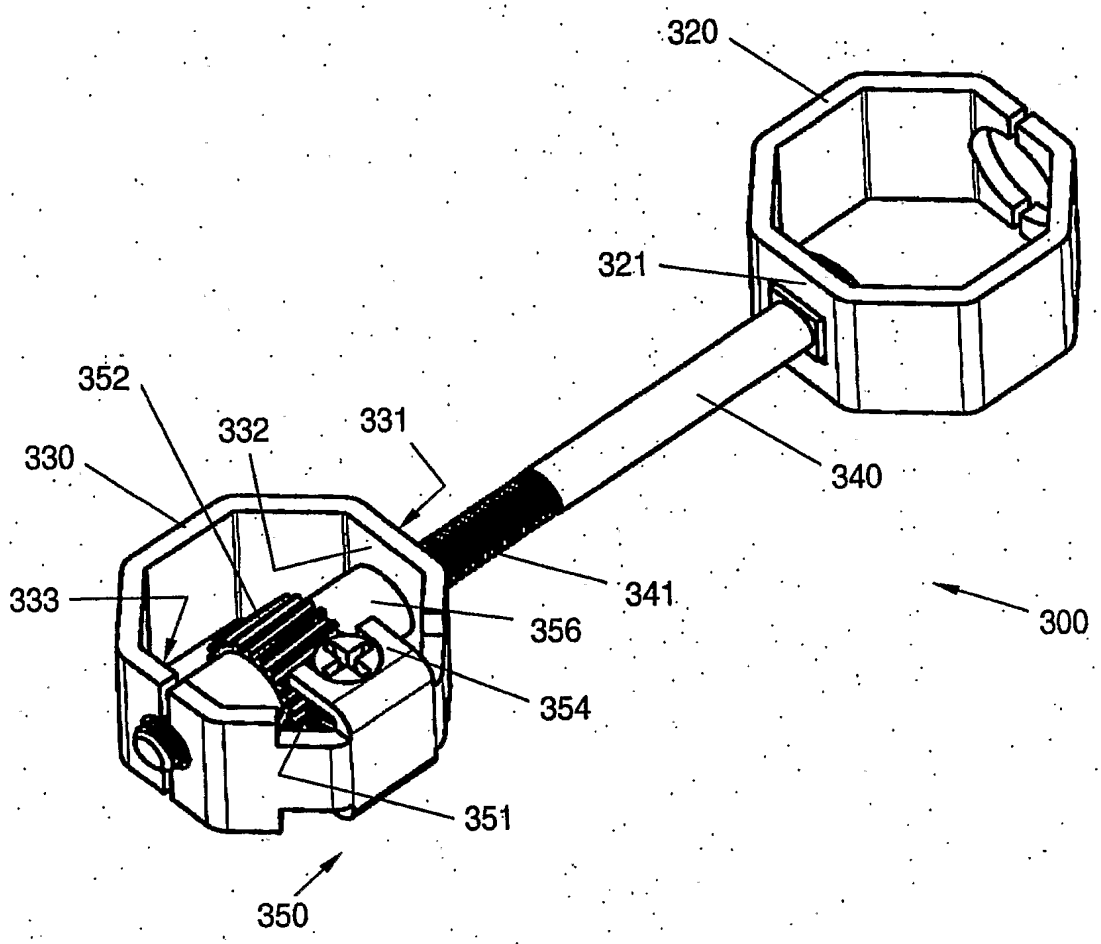

FIGURE 3

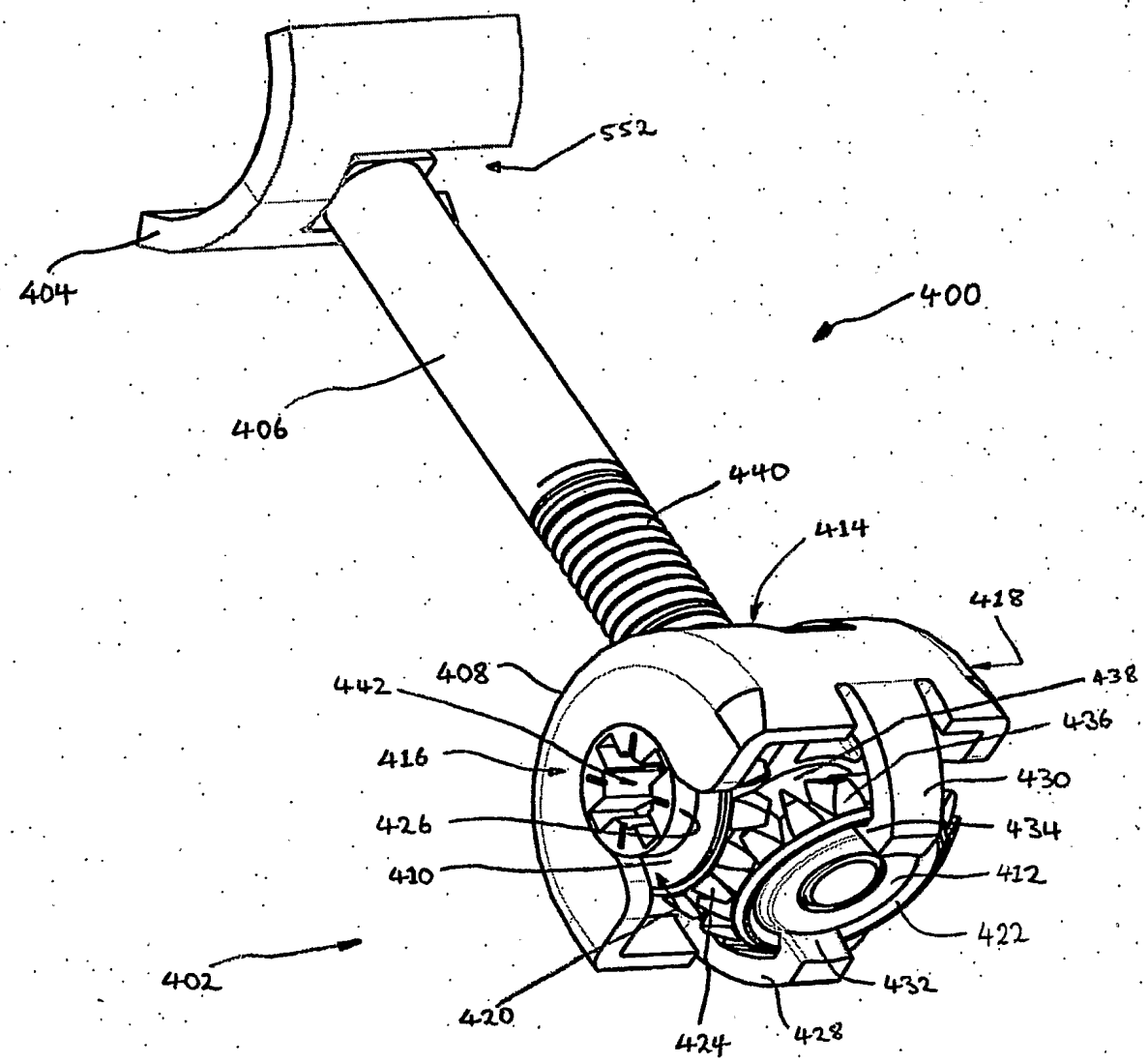
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FIGURE 4

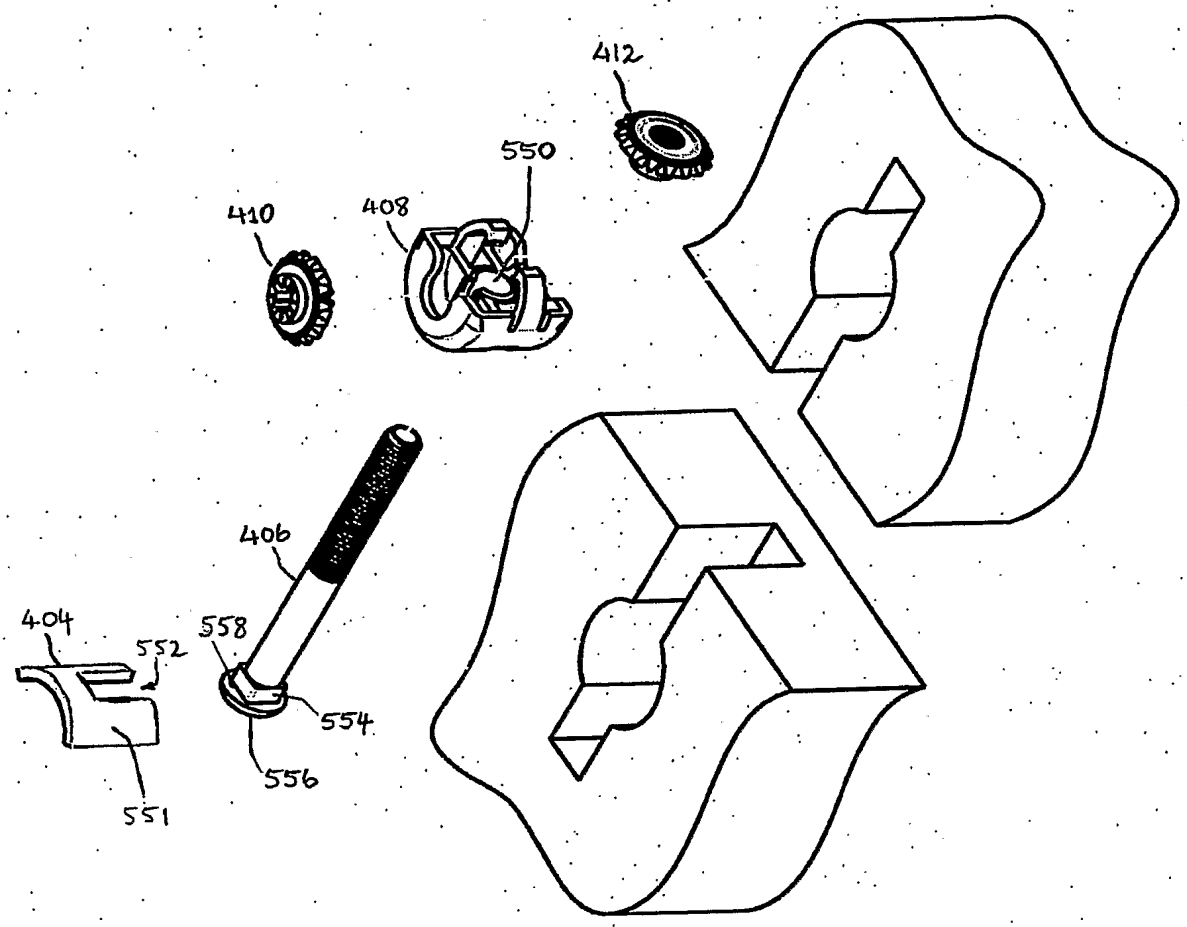

FIGURE 5

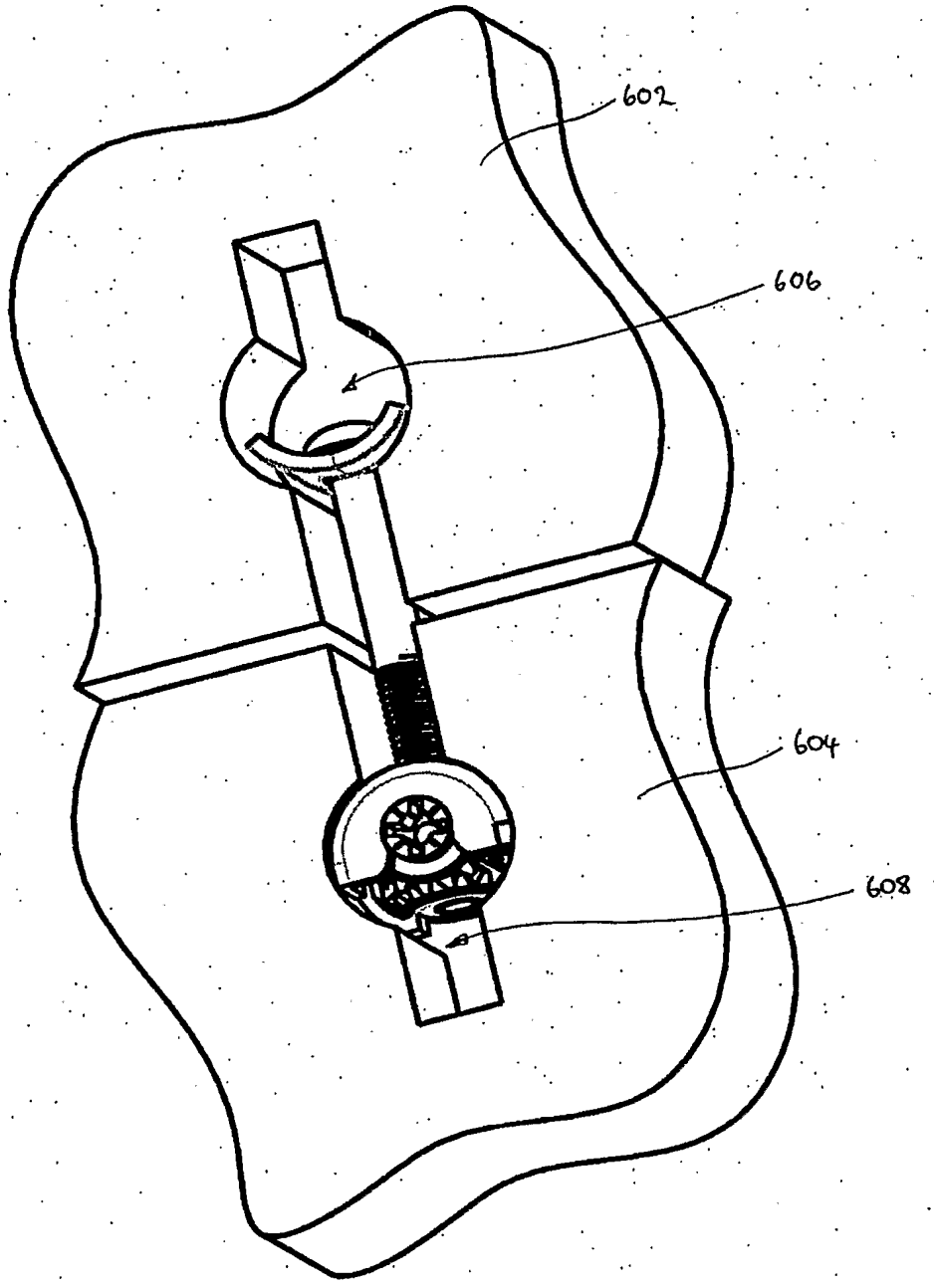

FIGURE 6